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# Research Progress 1969

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FOREST SERVICE  
CURRENT SERIAL RECORDS

Pacific Southwest  
Forest and Range  
Experiment Station

Forest Service • U. S. Department of Agriculture







**NASA photo**



## A LIVABLE HOME FOR MAN

The year 1969 has been one of major importance to those of us in forestry and related professions. Man set foot for the first time on the moon, and our own world will never be quite the same again. We saw an earthrise for the first time . . . a shiny, blue and white world adrift in the blackness of space. And that one look has given us a new perspective. We are reminded of our humble place in the Universe and of our total dependence on its natural forces. We have become aware of the weaknesses as well as strengths of 20th Century technology. Even in the distant and beautiful view from space, we have seen evidence of air pollution over southern California.

In the year just passed, we have also witnessed a growing concern about the quality of our environment—with population problems, air and water pollution, noise, natural beauty, open space, and waste. Young men and women in high schools and colleges seek a stronger voice in determining the kind of world they will inherit. They are not alone. Ecology has become the byword of conservationists, politicians, and government officials.

As a major part of our environment, forests and wildlands play a vital role in the total ecosystem that makes Earth a livable home for man. We have long recognized that forests are among the renewable natural resources. In the forest, you need not use and throw away. Nature is anxious to restore the mantle of vegetation if given a chance. In an era of plenty, the emphasis has been on harvest. In an age of scarcity, it shifts to growth and reproduction. The more we know about the natural forces at work in the forest ecosystem, the more we can encourage sustained forest productivity . . . and beauty.

We are adjusting our programs when the time is right to put more emphasis on the interactions among ecological factors. Some people call this interdisciplinary research. Research in the true fir forests of California's Sierra Nevada is one example. Studies of insect and disease problems of true fir, its growth and reproduction requirements, and methods of timber harvest to improve

water yield in these snow zone forests are parts of one broad investigation.

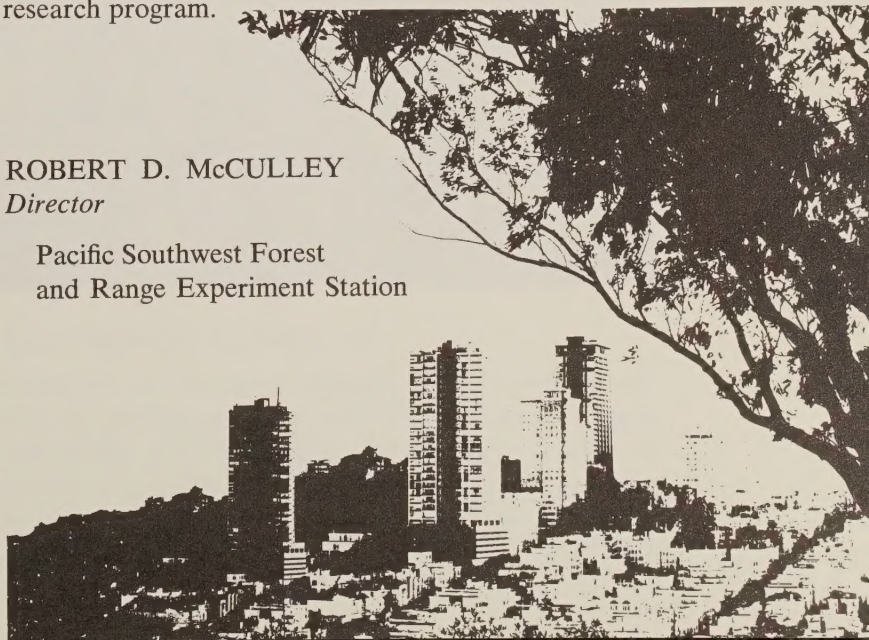
Research in the redwood forests of the north coastal region is another example. There, ecological studies will play a larger role in future research. And in Hawaii, whose principle attraction is nature's bounty in a climate favorable to lush vegetation, knowledge of soil, water, tree growth, and their interaction, aids the adjustment to a larger population.

In many of our other research programs, I think you will find new emphasis on interdisciplinary research, and on developing ways of managing the land which are more in harmony with nature. We invite you to read, for example, how wildlife habitat specialists are learning to use cattle grazing to improve bitterbrush range for deer in northeastern California. Entomologists are exploring the complicated chemistry of sex attractants to find more natural ways of controlling bark beetles. And pathologists studying smog-damaged forests in southern California are helping point out the hazards of air pollution.

This annual report is published because we want to share with you the exciting new directions in forestry research. I welcome your interest and your comments on the research program.

ROBERT D. McCULLEY  
*Director*

Pacific Southwest Forest  
and Range Experiment Station





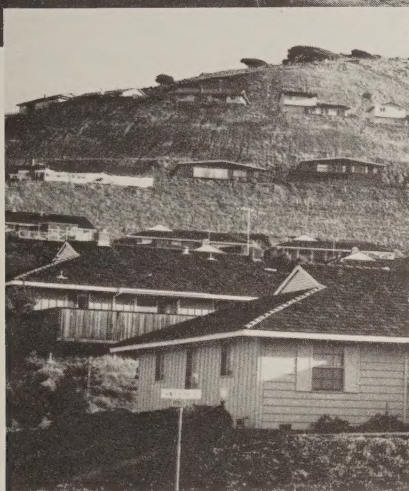
## Hidden Valley in Transition

A landscape analysis of Nicasio Valley in Marin County, California, has been completed and presented to landowners as a 50-page report, "Nicasio: Hidden Valley in Transition." The first study of its type in the western United States, it considers major environmental factors which might affect future development: geology, climate, vegetation, water, soil, wildlife, scenery, and historical and archeological sites. The plan was prepared for Marin County planners at the request of the local landowners' association. The valley is typical of much of rural America that lies within the reach of urban development. The study proposes a means of planning and development which should allow the valley to support more people, and still retain much of its original character.

2 The study, financed in part by a grant from the America the Beautiful Fund and the Forest Service, was conducted by researchers from the Pacific Southwest Forest and Range Experiment Station and the University of California.







When development occurs . . . does Nicasio have to become a future addition to Noplace, U.S.A.?



### Lake Tahoe Study Underway

Techniques of landscape analysis used in the Nicasio study are being improved and extended for a similar study of the Lake Tahoe Basin. The primary goal is to develop a technique for helping land managers predict and assess the impact of changing land use. Using the technique, land use alternatives can be evaluated as to their effect upon ecology and environmental quality.



### Color Photography Valuable for Ecological Studies

Remote sensing researchers continue to find advantages in color aerial photography for many kinds of forest surveys. Large-scale (1:1,584) color photographs in northern Minnesota show the ecological changes that have occurred in a balsam fir forest during a spruce budworm epidemic. Photos taken every two years for the past 10 years show the successional pattern clearly. As the insect population rose, the number of dead fir trees also began to increase. Most of the mature trees were killed and eventually fell. Downed timber was quickly covered by a thick tangle of vetch. At the end of the survey, researchers found hardwoods rapidly replacing the dead fir forest, with young fir seedlings lagging far behind. Color photography should also be a valuable tool to chart the ecological changes which follow logging, land clearing, fires, windstorms, and other types of insect or disease outbreaks.

### Multi-Stage Sampling Proves Useful

A multi-stage probability sampling technique designed for surveying beetle-killed forests in California has once again proved its value in obtaining estimates of timber loss at very low cost. The system was used to assess damage caused by the Black Hills bark beetle in the 1.35 million acre Black Hills National Forest in South Dakota. Aerial observations, color photography (scale 1:8,000), and sampling on-the-ground were used in the survey which cost \$3,040, or about 0.2 cents per acre.

### Portable System Developed for Photointerpretation

A portable system has been developed for measuring forest trees and mapping from aerial photographs. It consists of a Stereotape plotter, a portable desk-top computer, and a package of computer programs. The system should be a useful tool for resource managers who require accurate data from aerial photographs and cannot use large computer centers. The system can determine (1) model control data as well as the vertical and horizontal orientation of the stereotape; (2) elevation of any point in a stereo-model, contour settings, tree heights, crown diameters, slope percents, and road layouts to specified grades; (3) the orientation of aerial photographs; (4) plate coordinates from scale measurements,



Quality of the space image was good enough for interpreters to separate areas according to major timber type.

and (5) ground station coordinates from traverse data. To use the system, only a cursory knowledge of photogrammetry or surveying is needed since all the mathematical algorithms are pre-programed and stored on magnetic cards.

### Large-Scale Photos Detect Beetle-Killed Trees

Researchers have also found large-scale color aerial photographs (scale 1:7,920) best for detecting small groups of ponderosa pine trees killed by the Black Hills beetle. This conclusion comes from a two-year study in the Black Hills National Forest, South Dakota. Infrared false-color film is equally good for detecting dead trees, but less practical because inexperienced interpreters often have difficulty using this film. Dying trees cannot be detected at smaller photographic scales with sufficient accuracy. The small groups of dead trees are important to entomologists because they are an "early warning signal" that a beetle epidemic is imminent.

Remote sensing specialists also found that simulated space photography (scale 1:174,000) in both color and color infrared can be used to detect about half the infestations over 100 feet in diameter—the expected resolving power of most space imagery. The research has been conducted in cooperation with NASA's Office of Space Sciences and Applications.



## Space Photography Used in Forest Inventory

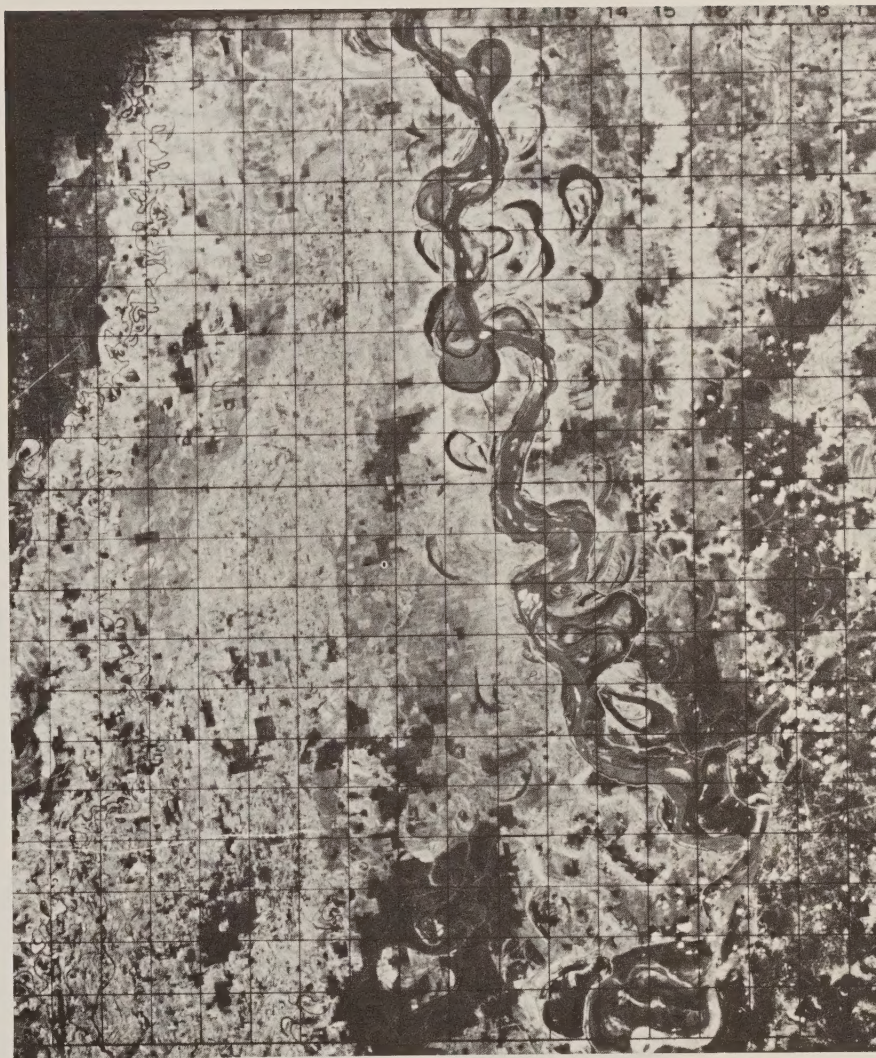
A forest has been inventoried for the first time using space photographs. The pioneering effort was made possible by photographs from the flight of Apollo 9 in March 1969, and a sampling technique designed by forest measurement and remote sensing units of the Station. The inventory was conducted over 10 million acres in Arkansas, Georgia, Louisiana, and Mississippi.

Researchers were interested in developing a method which can be used for future inventories. The technique they used is called multi-stage probability sampling. It employs several levels of aerial photography, plus ground sampling, and a sampling method in which heavily forested units are more intensively sampled. Best results were obtained on 5 million acres for which researchers figured the volume of timber at 2.225 billion cubic feet. The sampling error was only 42 percent of what it would have been without benefit of space photographs.

This survey could be the forerunner of a complete information system for inventorying forests from space. Scientists, working in cooperation with NASA, are now looking forward to the time when the Earth Resources Technology Satellite (ERTS) will be launched, probably some time in 1972. This space platform, designed to collect data on earth resources of all types, will make it possible to gather forest and agricultural data from space on a continuing basis.

## Tree Measurements from Aerial Photos

Tree heights can now be measured on large-scale aerial photographs (1:1,584) to within 3 feet of actual height. A cooperative study with the State College of Forestry, Syracuse University, indicates that in the future it may be possible to make even more precise measurements of tree height and other factors. Both small- and large-scale photography and highly accurate photogrammetric methods would be necessary. Several systems of lower accuracy are also being tested, with a cost-efficiency study to determine the best measurement system and photographic scale. Research results will have many applications in forest management and will help researchers evaluate the potentials of various photographic scales for multi-stage forest sampling.



The broad overview from space may someday enable forest surveys to be conducted more quickly, at less cost, and with greater accuracy than at present.



## Single Gene Controls Resistance to Blister Rust

Researchers working with tree improvement specialists from the California Region of the Forest Service believe they have found a few sugar pines which show exceptional resistance to blister rust, a serious disease of white pines the world over. A single gene appears to control immunity. This kind of simply inherited resistance is often found in crop plants, but only rarely in forest trees. It means that the inheritance mechanism is a simple one, and one that will make breeding rust-resistant trees relatively easy.

The finding is the result of 15 years of study and research aimed at selecting and propagating forest trees which show some natural immunity. Rust-free trees were selected and their offspring exposed to severe infections of blister rust. Most of the young trees are dead. But four parents have produced many offspring which are free of blister rust. Half the young trees from these parents are resistant and half are susceptible. There are no "in-betweens." This leads geneticists to conclude that they are working with a single dominant gene . . . one tiny messenger which, when present in the genetic code of the tree, gives it immunity to blister rust.

The finding is an important step forward in the war against blister rust. Since its introduction to this area over 40 years ago, the disease has severely damaged mature stands and all but eliminated regeneration of sugar pine in Oregon and northern California.

## Trees May Adapt to Forest Soils

Several years ago, a plant physiologist decided to test the theory that stands of forest trees are genetically adapted to the soils on which they grow. He reasoned that since many types of plants show this kind of adaptation, forest trees would, too. Investigating the adaptation of ponderosa pine to serpentine and non-serpentine soils, he has found evidence to the contrary. Serpentine soils are notorious for relatively poor growth of forest trees. But in his experiments, seedlings from several different seed sources showed the same first-year growth on both types of soil. However, differences may begin to show up in later growing seasons. The study has also shown that there are wide differences within a stand as to a tree's

ability to grow on serpentine and non-serpentine soils. If growth differences eventually prove to be significant, it may pay to consider soil as a factor in choosing seed sources for forest planting stock. Now major consideration is given only to elevation and climate.

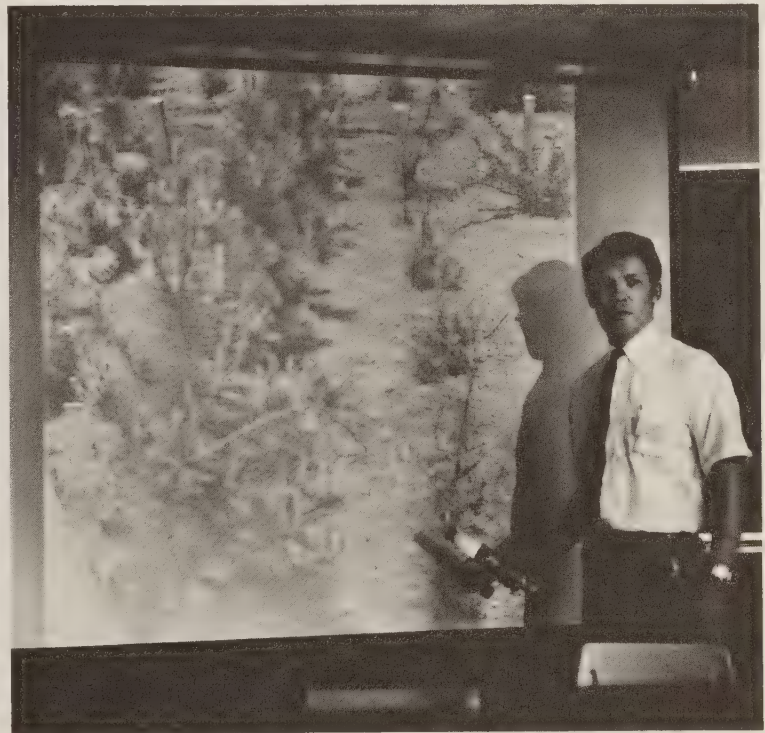
## Trees High in Limonene Resist Beetles

In their search for ways of controlling bark beetles, scientists are also exploring the possibility of breeding forest trees to resist attack by the beetles. But what factors are most important in determining a tree's resistance? There is substantial evidence that both resin quantity and quality are important. Recent tests support previous evidence that when resin flow is high, practically all ponderosa pine trees resist attack by the western pine beetle. As resin flow decreased, some trees showed greater resistance than others. The quality of the xylem resin then becomes an important factor. Trees with resin high in limonene resisted beetle attack longest. Trees high in delta-3-carene also showed more resistance than other trees. Tests were made by caging the stems of 40-year-old ponderosa pine trees and confining beetles to sections of the caged trees. Resin quantity was determined by the amount that flowed from a wound in a 24-hour period; resin quality was determined by the amount of the various monoterpenes.



### Hybrids Outgrow Ponderosa Pine

Ten-year-old hybrids of knobcone and Monterey pine are outgrowing ponderosa pine 3 to 1 in experimental plots at the Challenge Experimental Forest in Yuba County, California. Measurements taken over the past two years show that the hybrids average 35 feet tall, while ponderosa pines average 12 feet. The fast-growing hybrid was developed in 1927 through research at the Forest Service's Institute of Forest Genetics at Placerville. The hybrid combines the best qualities of two native conifers. It has good shape and form, and is both frost and drought resistant . . . a promising tree for growing on rugged Sierra Nevada foothill terrain. Increasing demand for wood may soon make the additional expense of planting hybrid trees practical on some forest lands in the West.



Forest geneticist Bohun B. Kinloch, Jr., has found evidence of a single, dominant gene controlling resistance to blister rust in sugar pine. Resistant parents (above left) pass on the inherited trait to their offspring (trees at left below).



### Hexadecanol Increases Rainfall in Hawaii

Watershed scientists in Hawaii have been looking for ways to get more water in drought-prone areas of the Islands. Natural fogs, which ordinarily do not produce rain, are a potential source. Research now indicates that it may be possible to increase rainfall artificially with a compound called hexadecanol. Twenty-five pounds injected into the clouds on Mt. Kaala, Oahu, produced a rainstorm over one square-mile which lasted for about half an hour. Hexadecanol is a simple carbon molecule used in lipsticks and other cosmetics.

This approach to rain making is new and based on studies showing that hexadecanol will make fog-size droplets grow until they are heavy enough to fall as rain. The compound is mixed with a volatile solvent and charged with electricity. As the solution is sprayed from a nozzle, the outside of the drop hardens, but the solvent continues to vaporize and build up pressure inside. When the pressure gets great enough, the drops explode. The resulting scatter of tiny electrically charged particles of hexadecanol attracts moisture and it rains.

Hexadecanol, sprayed into the clouds on Mt. Kaala, Oahu, produced the desired result—rain.

### Planted Forests More Productive

Planted forests cover some 40,000 acres in the State of Hawaii and contain about 300 million board feet of sawtimber. By comparison, the native forests, mainly ohia and koa, occupy about one million acres of commercial forest land, but hold only about 500 million board feet of sawtimber. This striking comparison comes from a series of reports on the planted forests of the major islands in the State. The final report, "Plantation Timber on the Island of Maui," was published this year. The reports provide much needed information on location and acreage of planted forests, species composition and age of stands, timber volume and quality, and ownership. Improving the forest resources of Hawaii through tree planting is one of the main goals of forest management and research in the Islands.

John Titchen photo





## Burned Watershed Recovers Quickly

Hawaii's lush and green subtropical forests are not immune to wildfire. Occasionally, fires burn over large areas. The effect on scenery is obvious, but little is known about the immediate or long-term effect on soils, water runoff, and vegetation types. To learn more about this aspect of the forest fire problem, scientists are studying the aftermath of a fire which burned 3,000 acres of mountain scenery above Hanalei Valley, Kauai, in June, 1967. Within 10 months after the fire, 90 percent of the area sampled was more than half covered by vegetation. There was no evidence of erosion. Patches of unburned litter on the ground and roots remaining in the soil apparently have prevented surface erosion.

## Wetting Agent Fails Major Watershed Test

Watershed scientists in southern California have been hard at work this past year, trying to explain why a wetting agent—applied to a 274-acre burned watershed—failed to reduce water runoff and erosion as expected. Their answers, still inconclusive, point out the difficulty of the fire-flood problem in southern California's steep brush-covered mountains.

The fire occurred in July 1968 in the San Gabriel Mountains above the town of Glendora. The wetting agent was applied by helicopter in November. Scientists had every reason to believe it would help break down a water-repellent soil condition found in the burned area. Previous laboratory and field tests had generally been successful. On a burned site in 1966, for example, an application of wetting agent reduced erosion by 40 percent and water runoff by nearly 60 percent.

Several reasons have been suggested for the ineffectiveness of the wetting agent in the most recent test. The first is the unusual severity of the 1969 winter storms. Rainfall during January and February was the heaviest since 1884. But research indicates this was probably not responsible. Erosion was about the same on treated and untreated watersheds both before, and after, the heavy rains.

Researchers thought that the wetting agent might have deteriorated by being exposed on the soil for 6 weeks

before the January storms. But the one study completed at this time tends to dispel that notion. The failure may also be attributed to the intensity of the water repellent layer in the treated watershed, or the nature of the water repellency. More intensive tests suggest that the eastern 50 to 75 percent of the treated watershed may have been substantially more water repellent than the rest of the study area. When treated with wetting agent, the soils from that area produced a different wetting pattern than had been observed previously. This suggests that it may be necessary to match different types of water-repellent soils with appropriate types of wetting agents.

Research will be intensified to: (1) investigate the persistence of wetting agents in the natural environment; (2) match soil characteristics with various agents to produce desirable wetting patterns; and (3) develop improved methods of evaluating water repellency in the field.

## 400 Seedlings Per Acre

Although methods of planting ponderosa pine in California forests are generally successful, researchers would like to increase the options available to the forester. Better techniques for natural regeneration or artificial seeding might help lower reforestation costs. In 5 years of study at the Challenge Experimental Forest, research foresters have found that one pound or more of pest-repellent treated ponderosa pine seed per acre consistently produced at least 400 seedlings per acre in direct seeding tests. This they judged to be an adequate number. Three hundred is too few; 600 would be better. Research is continuing, with emphasis on evaluating site and weather factors. Finding alternatives to the pest-repellent endrin to treat tree seeds will also be an important research consideration. Use of this chemical has recently been greatly reduced by the U.S. Forest Service.

In these same tests, researchers have also reinforced their prior conclusion that disturbance of the planting site helps get young trees established. Seedbeds of mineral soil created by mechanical disturbance were about 3 times more productive than seedbeds created by fire, and about 18 times more productive than undisturbed sites.



## Smog Damage to Forests Studied

An informal 3-year survey of major air basins in California indicates that smog-caused injury to forest trees is quite widespread. The most severe injury was observed in the south coast basin and portions of the southeast desert basin, involving the San Bernardino, Angeles, and Cleveland National Forests. Slight injury was evident in the northern section of Sequoia National Forest and at specific sites in the north central coast and San Francisco Bay air basins. Slight injury may be a possibility at Grass Valley and Placerville, near San Rafael, and at Torrey Pines State Park in the San Diego air basin.

Tree species with the most serious symptoms were ponderosa, Jeffrey, Coulter, and Monterey pines, and bigcone Douglas-fir. Knobcone pine was slightly affected. Damage is suspected in lodgepole pine, sugar pine, Torrey pine, white fir, and incense-cedar. No injury was observed in digger pine, single leaf pinyon pine, western juniper, redwood, or giant sequoia.

### 1.3 Million Trees Affected

An aerial survey of portions of the San Bernardino National Forest in southern California indicates that 1.3 million trees are being killed or injured by smog. Eighty-two percent are moderately affected, 15 percent are severely injured, and 3 percent are dead. The survey was conducted by our forest disease and remote sensing research units under a grant from the U.S. Public Health Service. Smog is damaging trees on some 100,000 acres of the ponderosa-Jeffrey pine type. Previous estimates had put the damage at about 25,000 acres. A multi-stage probability sampling design and large-scale 70 mm. color aerial photographs were used. Cost of the survey was \$3,265 or about \$.03 per acre.

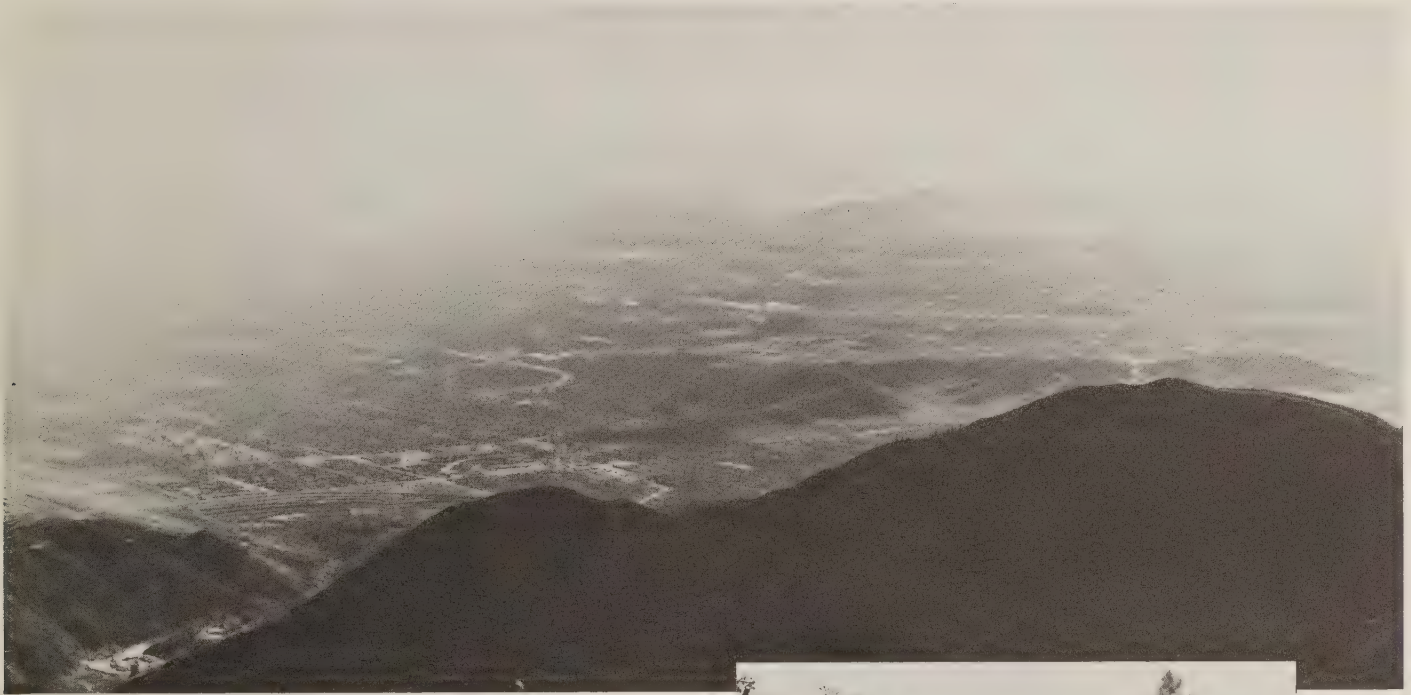
Researchers have also begun a study of the meteorological factors associated with smog damage to trees in the San Bernardino Mountains. Continuous records of total oxidant air pollution concentrations were made during June, July, and August 1969 at points along the south slope of the San Bernardino Mountains from Highland to Rim Forest. Temperature, dewpoint, atmospheric pressure, and wind measurements were also made. Data

will help establish the relationship between large-scale weather patterns and air pollution levels. Information will be used to develop a synoptic climatology of air pollution and help determine the damage potential at specific forest sites. Research is being conducted by the forest disease and fire meteorology research units.



Plant pathologist Robert V. Bega examines foliage of ponderosa pine tree damaged by smog in the San Bernardino Mountains of southern California. Needles turn yellow, eventually drop off. Above right: Smog blankets the Los Angeles Basin below Crestline in the San Bernardino Mountains. Onshore winds help blow the pollution cloud into the mountains.





In the woods, some trees show more resistance to ozone injury than others. In experimental chambers (above), young trees are exposed to either clean, filtered air or polluted air. Research will help determine which are resistant and which are susceptible.







Laser holography—one nanosecond exposure “freezes” action of insecticide droplets falling on a spruce budworm. The 3-D technique has given scientists more precise information about the way fine sprays behave.

### Acetylated Insecticides Show Promise

Zectran® is a nonpersistent carbamate insecticide currently being considered for use in controlling the spruce budworm and related forest insects. Though Zectran has a low dermal toxicity to mammals—of most concern for field use—it does have a very high oral toxicity. Chemists have found that by adding an acetyl group to the Zectran molecule, they can make it nontoxic to mice and other mammals without destroying its toxicity to insects. The acute oral toxicity of Zectran to rats is 13–65 milligrams per kilogram of body weight. With acetylated Zectran, researchers could get no mortality even at 2,000 milligrams per kilogram.

Even more important, chemists determined both how and why the acetyl group makes the compound harmless to mammals. Mice are able to metabolize the new compound into harmless residues, while insects merely split off the acetyl group and leave the Zectran intact. The finding will be extremely valuable in designing new, safer insecticides.

Further work on radio-tagged acetylated insecticides, including some of the nonpersistent organophosphates, shows that they are also more fat soluble than the original compounds. This means they may have valuable systemic properties. Fat solubility is an important criteria for getting insecticides through the waxy coating of forest tree needles.

### Insecticide Scientists Use Laser Holography

Aerosol-sized sprays, the kind found most effective for forest insect control, have previously been difficult to study because of the extremely small spray droplets. Now laser holography, a 3-D picture technique, has given scientists the most precise information yet about the way fine sprays behave. Researchers were able to see the droplets (as small as 5 microns in diameter) hitting the hairs of the insect, watch them coalesce, evaporate, or drop onto the insect. Operating at 1 nanosecond exposure (1 billionth of a second), the laser “shoots” pictures of the drops falling on the insects. Information is recorded by camera on a photo-sensitive glass plate. When the plate is inserted in a reconstructor, it projects the hologram on a TV screen for study. With the recon-



structor, images on the hologram are brought in and out of focus in sequence, much as objects are viewed and focused in a microscope. All planes of the image can be studied in a three-dimensional fashion. The research will help in designing insecticide spray formulations and application techniques.

### Needle Miners Increase in Yosemite

Entomologists are predicting increased damage to forests in Yosemite National Park from the lodgepole needle miner. Severe defoliation of 700 to 1,000 acres of lodgepole pine forest near Tenaya Lake recreation area is expected in the summer of 1971. These predictions are based on study of insect epidemics in the Park since 1955. In 1965, entomologists witnessed a near total collapse of needle miner populations. Decline was associated with cool, rainy weather during the reproductive phase of the moth's life cycle. During the past few years, entomologists found several "refuge areas" where insect populations were still comparatively high. They suggested that these sheltered breeding areas, protected from wind and cold, are the source of future epidemics. Now their theory seems to be borne out. Warm, dry weather during the summer of 1969 favored insect reproduction. In sheltered areas, newly established populations are  $2\frac{1}{4}$  to  $4\frac{1}{2}$  times higher than the previous generation.

### Sex Attractants Made More Potent

Sex attractants continue to show promise as a method of controlling bark beetles, the number one forest insect problem in the western United States. Potency of the synthetic attractant for western pine beetle has been increased until it is as attractive as the most potent natural sources. Five beetle-produced compounds and a long list of those manufactured by the tree have been implicated as components of the attractant. Each has been field tested alone and in various combinations with compounds ranging from highly attractive to unattractive. The most attractive mixture contains only three compounds—brevicommin and frontalin, which are both produced by the beetles, and myrcene—a compound produced by the host tree. Research has progressed to the point that field tests are planned during the summer of 1970 to determine the usefulness of sex attractants as a method of insect control.



Entomologist Thomas W. Koerber predicts an outbreak of lodgepole needle miner in Yosemite National Park in 1971. Prediction is based on study of insect populations.





Mule deer depend on bitterbrush range in southeastern Oregon and northeastern California for winter survival. Deteriorated range may be improved by carefully controlled cattle grazing.

### **Fomes Annosus Study Completed**

A study of the forest tree root disease *Fomes annosus* was completed this year by forest pathologists working in 7 National Forests and 1 State Forest in California. Purpose of the study was to find out how fast the disease is spreading from known infection centers. Average linear extension of the damage was found to be about 3.5 feet/year, except in the San Bernardino National Forest where spread was 8.4 feet/year. Largest infection centers were found on the Cleveland National Forest. Some were over 100 acres in size. The fungus, which attacks all western conifers except giant sequoia, is of special concern to foresters now because world-wide experience has shown that the disease increases as forests are more intensively managed. It spreads from the roots of felled timber to adjacent young trees. Foresters fear that if the fungus is allowed to spread, large areas of forest land will become unsuitable for growing trees.

The study will enable pathologists to predict the losses that might be expected from the disease in an area over a given time. Researchers also found evidence that the fungus, once established, does not die out quickly. In the Lassen and Cleveland National Forests and at Boggs Mountain State Forest, *Fomes annosus* was found in roots of trees cut 30–50 years ago.



## Fungicides Help Control "Damping Off"

Several years of testing soil fungicides at the Placerville Forest Tree Nursery indicate that PCNB-Terrazole and PCNB-Dexon are more effective than some other compounds in controlling "damping off" of pines. The condition is caused by the many types of forest tree pathogens which attack the succulent young stems of seedlings in the nursery. In most years, soil fumigants—which are applied to the soil as a gas—are used quite successfully to control the disease. But fumigation requires a 2-week waiting period so the chemical can escape from the soil before planting. If a spring is unusually long and wet there may not be time to fumigate before planting. Fungicides, which are applied dry or in solution, require no waiting period and can be used in wet years.

## Deer Range Improved by Cattle Grazing

Bunchgrass-bitterbrush rangelands in northeastern California and southeastern Oregon do double duty as summer range for cattle and as winter range for large herds of mule deer. Bunchgrass is a mainstay of the cattle diet; bitterbrush is the principal food for deer.

Over the years, much of the range has declined as a source of food for deer. Natural bitterbrush reproduction is almost non-existent. Now it appears that heavy early-season grazing by cattle may be a good way to improve the condition of bitterbrush range. This conclusion is the result of 4 years of grazing tests on sixteen 5-acre units—eight in Modoc County, California, and eight in Lake County, Oregon. Wildlife habitat researchers sought a combination of season and intensity of livestock grazing which would reduce bunchgrass and improve the reproduction and growth of bitterbrush.

Under heavy early-grazing, cattle are put on the range as soon as possible in the spring, and left until they have removed 95 percent of the current growth of grass. This usually takes from mid-April to early June. This treatment reduced the grass stand by 50 percent and bitterbrush only slightly at both study sites. The same study showed that moderate, season-long grazing—as generally practiced—allows perennial grass to increase at the expense of bitterbrush.



Research indicates that heavy early grazing by cattle will reduce bunchgrass and improve reproduction and growth of bitterbrush.





### Wind Jet Explains Erratic Fire Behavior

A phenomenon sometimes observed in forest or brush fires is a wind that appears to blow out of the fire front—contrary to the normal indraft. Because it can cause a fire to spread faster than expected, or raise havoc with backfiring operations, it is a troublesome factor in fire control. When this phenomenon appeared in the Walker Basin Fire near Temecula, California, on August 22, researchers were able to study one set of conditions that can lead to its onset.

During the afternoon, the fire was driven by a strong northwest wind. Shortly after sundown the wind died, but the fire continued to move as rapidly as ever. Data obtained from pibal soundings near the fire showed that the northwest wind was actually in the form of a jet about 5,000 feet thick. After sundown the surface air cooled enough to raise the jet about 500–800 feet above the surface. But the turbulence and hot air at the fire front permitted the jet to surface in that area, driving the fire forward. In the early morning hours the jet ceased and the fire was quickly controlled.

Wind jets are difficult to detect without instruments for upper air observations, but smoke behavior may give fire bosses an indication of their presence.

### Crystalline Structure Important in Burning Process

Research chemists studying the complex process of cellulose combustion have found that crystallinity may be an important factor in determining how readily a material burns. The information should help in developing forest fire retardants or fireproofing treatments.

Researchers had previously determined that cellulose breaks down by two competing reactions which lead to either flaming or glowing combustion. These reactions were found to be highly sensitive to small amounts of impurities. Now researchers also believe that crystalline structure affects flaming and glowing. The process leading to flaming combustion, they believe, is a depolymerization or “unzipping.” Upon heating, each of the monomers of the molecule peels off, one at a time, down the chain. Glowing combustion, on the other hand, is the result of an “intermolecular dehydration.” Water within

the molecules is split off first and vaporized. A bond forms between the remaining molecules, creating units which are too large to vaporize. This results in char formation and burning by glowing instead of flaming.

Ordinary cellulose has both crystalline and amorphous regions. Because the molecules in the crystalline regions are lined up evenly, intermolecular dehydration occurs more readily—with an increase in char formation. Amorphous cellulose flames more readily. Substances which can increase the crystalline character of cellulose either at room temperature or on heating, should therefore inhibit flaming combustion.



**Chico Enterprise-Record**

First graders at Aymer J. Hamilton School in Chico learn the essentials of forest fire protection. Classes are the result of research which has shown that most children-caused forest fires are started by very young children.

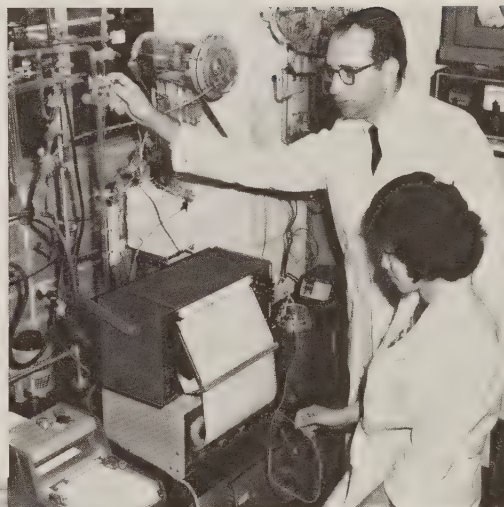


## Fire Prevention Gets a Headstart

In an effort to reach young children with the fire prevention message, special educational materials are being developed and tested. The effort is aimed at combatting the serious problem of children playing with matches and starting forest fires. Almost one quarter of all man-caused forest fires in California are started by children. Research has previously shown that most of these fires are started by very young children.

The California Division of Forestry and Headstart teachers from Riverside County have designed a course especially for the pre-school level—ages 3½ to 5. The course, which emphasizes care with fire and the value of forest resources, was given to 600 students in Headstart classes in Riverside County. Results were evaluated by researchers from the Pacific Southwest Forest and Range Experiment Station. The materials were enthusiastically accepted by both children and teachers. Older children, the five-year-olds, absorbed significantly more of the information than younger children. Suggestions from teachers and observers will be incorporated into the program.

Los Angeles Times



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Fire behavior teams from the Forest Fire Laboratory at Riverside, are available to California fire control agencies for help in predicting fire behavior. Above left: Chemists determine the combustion properties of amorphous cellulose using thermogravimetric analysis equipment.



### Laser Used in Fire Research

A low power, helium-neon laser has proved to be a valuable research tool, enabling scientists to analyze the structure of experimental fires with new precision. Highly versatile, it can be used to study the temperature gradient of a fire, its air speed, the distribution of smoke particles, and sound characteristics associated with a fire. With the laser, scientists have made the first measurements of "optical depth," a precise indicator of the distance objects can be seen in smoke. Optical depth varies from 30 to 100 feet. Roughly, this means that a person would have trouble distinguishing one object from another at 60 feet. At distances over 200 feet, there would be complete disorientation.

A low light level, silicon-diode vidicon used as an image tube in a TV camera also shows promise for use in research and fire control. It operates in the near infrared spectrum and can take pictures at night. A vidicon system, much less expensive than other available systems, might be practical for forest fire detection or to map fires when darkness, smoke, or haze obscure the aerial view.

### Acid Breaks Dormancy of Creeping Sage

Creeping sage (*Salvia sonomensis*) is a low-growing perennial which shows promise for planting in fuel-breaks or around campgrounds to reduce fire hazard. Researchers have found that 40 percent of stem cuttings will root and survive in the field. But cheaper and faster techniques will be necessary if large-scale planting programs are undertaken. Researchers found that only 3 percent of the seeds will germinate unless the seed coat is removed, so they tried several methods of breaking dormancy: cold stratification, scarification, and treatments of sulfuric acid, thiourea, hydrogen peroxide, and gibberellic acid. Cold treatments broke dormancy in 3 months, but the method is not very practical. Gibberellic acid was the second best treatment. Forty percent of seeds germinated after soaking in a concentration of 100 parts per million for 15 minutes. Lengthening the soaking time to one hour increased germination to 60 percent, but there was no advantage in increasing the acid concentration.



Portable mixing unit for fire retardant helps bring helitankers to the fireline.

### Mobile Fire Retardant System Developed

Large helicopters with the capability of carrying several hundred gallons of fire retardant are becoming increasingly available. Some day they may replace fixed wing air tankers. But big helitankers can be too expensive unless operated with a very short round trip. This means that mixing plants for retardants must be set up as close to the fire as possible. How do we get retardant to the fireline? Mixing dry bagged powder requires too much manpower, and liquid retardants are too bulky and expensive.

In a joint effort with the Monsanto Chemical Company, the San Dimas Equipment Development and Testing Center, and southern California fire control agencies, researchers developed and tested a system which appears to solve the problem. It consists of a mixer unit in which compressed air "fluidizes" bulk dry-powdered retardant, permitting it to flow into a suction system where it is mixed with water. The result is instant fire retardant, ready for use at the heliport. Although the unit has been used on only one major fire, results were so favorable that the Los Angeles County Fire Department has contracted for a second. The mixer can also fill fire trucks, supply its own fire hoses, and serve as an emergency base for air tankers.



## Prescribed Fire in Chaparral

Periodic burning of chaparral on mountain slopes has frequently been suggested as one answer to southern California's big fire problem. Fire researchers are conducting a series of controlled burns in chaparral to learn more about how to reduce fire hazard, at least on limited areas. They emphasize that brush must be prepared for spring burning and precautions taken to prevent the fire from escaping. They are trying various ways to treat brush—with desiccants, for example, and smashing strips by tractor—to dry out stems and leaves. In the 1969 trials, ignition was under carefully prescribed weather and fuel conditions: temperature, 80° F.; relative humidity 26 percent; and winds not more than 10 miles per hour. Fuel on dozer-smashed strips, fine desiccated fuels, and dead fuels burned completely. About 88 percent of standing live chamise, 70 percent of manzanita, 47 percent of mountain mahogany, and 35 percent of scrub oak, was consumed. Further tests of prescribed burning are planned for 1970.

## Regulations Set for Slash Burning

A system for regulating burning of logging slash based on smoke dispersion conditions has been completed and placed in effect by all fire control agencies in western Oregon. It gives foresters guidelines for slash burning based on weather conditions and the proximity to major population centers. The system was developed jointly by the Pacific Southwest Forest and Range Experiment Station and the Pacific Northwest Region of the Forest Service, with the cooperation of the Oregon State Forestry Department, Oregon Forest Protection Association, Bureau of Land Management, and the Bureau of Indian Affairs. Unlimited burning is permitted when winds will carry the smoke directly away from the more heavily populated portions of western Oregon. If winds are variable or toward a designated "smoke sensitive" area, burning is limited by factors such as distance from the area, anticipated elevation of the smoke layer, and the depth of air currents through which the smoke will mix. The new system is essential if prescribed burning is to continue under new and more stringent air quality regulations.



Added maneuverability enables helicopters to drop fire retardant with greater accuracy.



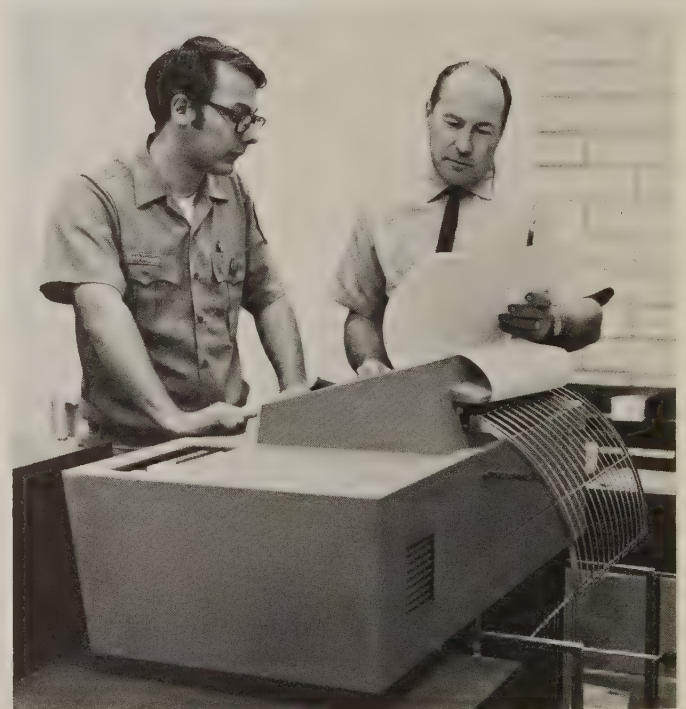
### **RCS Helps Watershed Planners**

The Watershed Systems Development Unit is nearing completion of another series of computer programs, called Resource Capability System, which can be used for watershed planning in the National Forests. Goal is more effective watershed management and protection. RCS can help forest land managers decide what land uses to put on each unit of land, determine how various treatments will affect factors such as water yield or sedimentation, and determine the best set of management alternatives to meet watershed goals. RCS is designed to develop and analyze new data. The system may have potential for broader resource planning for Ranger Districts, National Forests, and Regions as well as individual watersheds.

### **Computer Aids for Fire Control**

Fire researchers have developed several new systems for applying computer technology to forest fire problems. One is a system which can help fire bosses make decisions about the best use of limited manpower or equipment. The new computer program can take a suppression plan from the fire staff and evaluate its chance for success while making optimal allocations of firefighting forces. Computer capabilities can be brought to the fire by a typewriter terminal connected over phone lines to a computer center. Another possibility is to mount a small computer in a trailer or van for use at the fire camps.

A computer program has also been developed that can solve problems of fireline construction. Given four factors—such as number of men or bulldozers available, length of fireline to be constructed, the desired rate of clearing, and the probability or confidence level for success—a fire boss can quickly determine a fifth factor, how long the job will take. Given any four of the variables in this system, the computer can quickly compute the fifth. The data used in this program are based on a 3-year study of rates of fireline construction in California forest fire situations. Results indicate that expected rate of fireline construction is more related to length of time on the job than to forest fuel or terrain factors.



Computers are an everyday tool for researchers studying ways to apply computer technology in forest fire control.



## Computer Help for Timber Managers

Timber-RAM, a resources allocation model for planning the management of commercial forests under multiple-use guidelines, has been successfully tested and is being used by several units of the Forest Service and some private foresters. It uses electronic computers to determine the forest cutting schedules which best fit the land manager's goals. The model can be used to develop several management plans based on different combinations of timber practices and policies. For example, foresters can study in advance the economics of different rotation patterns or of commercial and precommercial thinnings. Other considerations—too complex or subtle for the computer—can be brought to bear in the final selection of a management plan.

Researchers plan to develop systems for management of other wildland resources as quickly as possible. Eventual goal is a Resource Allocation Model for complete multiple-use planning.

To make a system like RAM work effectively, better ways to collect, display and retrieve resource data are needed. The basic framework of a Wildland Resource Information System (WRIS) has been set, and work begun on the mathematics involved in converting map and chart data into input suitable for the computer.



Bendix Corp. digitizer is a valuable new tool for converting map and chart data into input suitable for the computer.



### How Much Water Does a Tree Use?

Trees use a lot of water in the process of growth and wood production. The amount of water used and consequently the amount available for "saving" through timber harvest is difficult to determine. There is no direct way to determine the amount of water a tree uses. But an attempt has been made to estimate the rate of water passage through individual trees with radioactive tracers. Estimates made from this technique indicate that one lodgepole pine tree used water at a rate of about 6.6 gallons per day during the month of October. The tree was 9.8 inches in diameter, and growing at 6,700 feet elevation in the central Sierra Nevada. Water use in October is normally at its lowest point—after the growing season and after most available moisture in the soil has been used. Extending the data to a similar-sized lodgepole pine stand, researchers estimated that 1 acre of fully stocked lodgepole pine forest would use roughly 50,000 gallons of water in October. A large portion of this water would normally be released for downstream use if the stand were cut. Research will help forest managers determine the impact of streamflow of timber harvest in mountain watersheds.

New computer program helps forest land managers predict the level of use at winter sport sites.

### Computer Predicts Winter Sports Use

New in the family of computer programs to help forest land managers is one which can predict levels of recreation use at winter sport sites, either existing or proposed. The program is based on data collected at 26 winter sport sites in California National Forests, and on the population and socio-economic characteristics of all California counties. The program has been tested for three proposed ski area developments in California and found to be an effective aid to decision making. Other uses for the program may include predicting levels of use for campsites, water sport sites, or other outdoor recreation areas.







### **Snow Holds More Water**

The amount of liquid water which can be held in snow is much greater than previously thought. Past research has indicated that snow can only increase its density by 0.02 to 0.05 grams per cubic centimeter as a result of adsorbing and absorbing liquid water. New studies show that it will actually increase by 0.2 to 0.20 grams/cc., depending on the pore space of the snow and the amount of water already in the snow. Pore space is determined by: (1) the weight of overlaying snow; (2) the melting and freezing action which took place while the layer was on the surface; (3) the amount of water frozen in the snow; and (4) the amount of "free" water already in the pack. If daily "profiles" of the snowpack are taken, it should be possible to estimate the amount of new water which the pack can absorb at any time. The research will be useful in developing new theories to predict snow-melt, to determine the effect of timber harvest on snow-melt, and for flood forecasting and water reservoir management.

### **Homeowners Prefer Crawl Space**

A study of preferences for floor foundation designs has brought out an interesting contradiction. Although homeowners prefer floor systems with crawl space, they often get concrete slab systems. The study was conducted by marketing researchers at the Pacific Southwest and Southeastern Experiment Stations.

Crawl space systems normally use between 2,000 to 3,000 board feet of lumber, plywood, or other flooring products per home. Concrete slab systems take significant volumes of wood from the home construction market.

The contradiction showed up in a survey of the southwestern United States. Researchers found that builders in Phoenix, Arizona, use concrete slabs almost exclusively. Home builders in the San Francisco Bay Area prefer crawl space systems. Construction cost, site conditions, and other design factors, influence builders' preferences. But homeowners universally indicated preference for crawl space designs.

Results of the study will help researchers evaluate experimental designs for plenum floor foundation systems (those that use air space beneath the floor in lieu of ducts for forced air heat), and help builders and architects plan future home designs.

### **Radio Communications Studied**

A study of the U.S. Forest Service's radio communications network has been completed by the Management Sciences Staff assigned to the Pacific Southwest Forest and Range Experiment Station. Conclusions are based on a study of fire communications traffic on two National Forests in California and general radio traffic on four Forests. Researchers studied the rates of call placement, duration of calls, the mechanics of repeat placing of calls, and the number of calls lost because of traffic tie-ups. Results indicate that the present system is operating adequately, with a tolerable number of lost calls. But as radio traffic increases, the system will require major changes. Recommendations for future improvements in the system are included in two reports to be published soon.





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Further information on the research program may be obtained by writing to Information Services, Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service, P.O. Box 245, Berkeley, California 94701



